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Report No. AAEE/Tech/122/Nav. Part II

MINISTRY OF SUPPLY

AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT

BOSCOMBE DOWN

FC

EVALUATION OF BLUE SILK/G.P.I. MARK 4A - PART II

PERFORMANCE OVER VARIOUS TERRAINS AND UNDER SIMULATED OPERATIONAL CONDITIONS

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Report No. A&AEE/Tech/122/Nav. Part II

AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT
BOSCOMBE DOWN.

31. MAY. 1956

Evaluation of Blue Silk/G.P.I. Mark 4a - Part II

Performance over Various Terrains and under Simulated Operational Conditions.

A. & A.E.E. Ref:- S.170/44/Nav.

M.O.S. Ref:- 7/WT/3002.

Period of Trials: September - December, 1955.

Summary.

The report on the first phase of the Blue Silk/G.P.I. 4a acceptance trials has already been issued.[1] This report covers the second phase, and consists of an evaluation of the performance of the equipment over various terrains and under operational conditions, and of the Pilots Track Indicator.

The performance of Blue Silk was quite satisfactory over all the terrains tested, except over particularly steep mountains. The equipment was satisfactory when used tactically in the height band 250' - 350'.

The accuracy of the system was tested on long single track flights and during tactical search patterns. On the long single track flights the mean navigation error, (which includes that attributed to the compass), was just under 2 n.ms. per 100 n.ms flown for sorties over both land and sea. The mean error during the tactical flights was approximately $2\frac{1}{2}$ n.ms. per 100 n.ms. flown.

The track indicator was not found to be of great value in its present form, except for tactical flights involving many changes of track.

The resolution accuracy of the G.P.I. 4a was also tested on Latitude and Longitude presentation during simulated runs on the ground and was found to have a high order of accuracy.

This Report is issued with the authority of

Air Commodore
Commanding A. & A.E.E.

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1. **Introduction.**

1.1 The Ministry of Supply requested A. & A.E.E. to carry out combined M.O.S./Service acceptance trials of Blue Silk/G.P.I. Mk.4a in a letter Ref. 7/WT/3002 dated 16th September, 1953. It was decided to conduct the trial in two parts as follows:-

(a) Phase I - Handling and Basic Accuracy under ideal conditions. This was the subject of Report No. AAEE/Tech/122/Nav. Part I dated 30th December, 1955.

(b) Phase II - System performance under operational conditions over various terrains.

1.2 Phase II of the trial, which forms the subject of this report, took place between 5th September and 7th December 1955, on which date the trials aircraft, Shackleton 1 VP.285, became due for a minor inspection. During the inspection the aircraft was found to be suffering from corrosion and was assessed category 3 (repair). In view of the time delay involved and the small amount of trials work remaining, it was decided to terminate the trial at this point. During Phase II of the trial, the equipment was flown on 13 trials sorties, 12 air tests and miscellaneous sorties for a total of 108 hours 20 minutes. The report includes a brief description of the installation and calibration of the trials and test equipment, followed by an assessment of the performance of the Blue Silk/G.P.I. 4a/G4B system during long range flights over various terrains and in various climates. The work on performance in turns, initiated in Phase I, was continued in Phase II (but not completed owing to the aircraft unserviceability mentioned above) and is examined, together with performance during typical search patterns.

2. **Installation of the Equipment.**

2.1 Operational Equipment. The Blue Silk aerial, transmitter/receiver, tracking unit, power unit and discriminator remained in their original position on the floor of the rear fuselage, as for Phase I of the trial, but the Indicator, Mileage Counter, G.P.I. 4a, G4B Compass and A.C. and A.G.C. voltmeter were installed in a more suitable position on the navigator's table (Fig. 1). The A.C. voltmeter monitored the output from the Type 103 Inverter to the Blue Silk equipment and the A.G.C. voltmeter gave readings related to the strength of the received signal. The latter had been found during Phase I to give a better warning of the imminence of unlocking of the equipment than the red light on the Indicator Unit. A pilot's Track Indicator was added above the 1st Pilot's cockpit coaming (Fig. 2).

2.2 Datum Equipment. For the Phase II flying, the primary consideration was for fixing accuracy in order to determine the overall system error. Decca was used wherever possible but outside its coverage, visual pinpoints were used, (except on the flight between Gibraltar and Lisbon where astro and A.S.V. fixes had to be employed). As the majority of the flying was carried out at heights below 2000 ft. the error in pinpointing by an observer in the bomb-aimer's position was considered insignificant compared with the length of each leg assessed. The Azimuth Datum Instrument Mk. 2^2 was used as the heading datum for an air calibration of the G4B Compass and alternated with a periscopic sextant as a heading check during the overseas flights.

3. **Alignments and Calibrations.**

3.1 **Blue Silk Aerial Alignments.** The aerial was aligned by the method detailed in Appendix "F" to Report No. AAEE/Tech/122/Nav. Part 1, and the voltage output through the G.P.I. and Blue Silk asynn transmitters checked before the commencement of Phase II flying and between the two overseas flights. During the last check, the G.P.I. asynn was found to be transmitting an error of 0.1°S to the G.P.I. and this error was removed. It was considered unnecessary to remove errors in the Blue Silk asynn, (which were 0.17°P, and 0.20°P respectively) since they would not be included in the Phase II accuracy figures which depended solely upon comparison of the G.P.I. reading with the true geographical position.

3.2 Compass Calibrations.

3.2.1 The G4B compass was calibrated on six occasions as follows:-

(a) Prior to first overseas flight on 2.9.55. (flight No. 1)
(b) At El Adem on 8.9.55.
(c) Prior to second overseas flight on 26.10.55. (flight No. 7).
(d) On 18.11.55 before the air calibration at (e).
(e) Air calibration on 22.11.55.
(f) On 23.11.55 after the air calibration at (e).

3.2.2 All ground compass calibrations were carried out using the Watts Datum Compass. The maximum 50% error of determination of deviation on any single heading was $\pm$ 0.10°. The graphed deviations for the calibrations listed in sub.Paras 3.2 (a), (b) and (c) are given in Fig. 3 and those for sub. paras 3.2 (d), (e)&(f) are given in Fig. 4. The results of the calibrations are very consistent, and the reduction in the residual deviations found at El Adem can be attributed to the lower magnetic latitude.

3.2.3 Results obtained in Phase I of the trial tended to indicate that there might be considerable changes in the value of deviation between the ground and air conditions. It was therefore decided to carry out an air calibration using the Azimuth Datum Instrument Mk. 2. This was done on 22nd November, 1955, and ground calibrations were done on 18th and 23rd November for comparison. The graphed deviations for these three calibrations are shown superimposed in Fig. 4. It will be seen that the three curves are similar in shape, but that the maximum value of deviation in the air is less than that found on the ground. The 50% error of a single observation of deviation for the air calibration was $\pm$ 0.16°.

3.3 Alignment of the Azimuth Datum Instrument. The A.D.I. was aligned with the aid of a theodolite as in the Blue Silk basic accuracy trials (AAEE/Tech/122/Nav. para. 4.2). The 'A' correction was found to be -39.69°, compared with the previous figure of -39.72°. However, the A.D.I. mounting had been removed from the hatch, and the hatch from the aircraft, between the two calibrations.

3.4 Alignment of the Periscopic Sextant Mount. This was fitted in the rear escape hatch when the A.D.I. was not in use. The alignment error was calculated by comparing the bearing of the sun from the aircraft's fore and aft axis, as measured by the periscopic sextant, with the same angle measured by a Tavistock theodolite, a series of simultaneous observations being made over a four minute period.

4. Conduct of Phase II Flying Programme.

4.1 Object of the Flying. The flying in Phase II was carried out with the dual object of obtaining figures for the overall Blue Silk/G.P.I.'4a/G4B system accuracy on long flights in conditions as near as possible to those likely to be encountered in Coastal Command operations, and evaluating the performance of the equipment over widely differing types of terrain. The flying programme therefore included a number of long, straight flights, representing the cruise from base to the operational area, and a selection of shorter flights over the sea areas around the United Kingdom when tactical search patterns were carried out. A brief narrative of each flight is included in para. 5.3

4.2 Choice of G.P.I. Presentation. As all the flying in Phase I had been carried out using the grid presentation on the G.P.I. 4a, it was decided that the majority of flights during Phase II should be carried out using the other two presentations. The "Along and Across Track" form was therefore used for all flights consisting of one straight leg or of return flights along the same straight leg. Latitude and longitude presentation was used on all other flights except for the Arctic sortie, when "grid" was used in conjunction with normal grid navigation procedure on a Lambert Conformal plotting chart.

5. System Accuracy.

5.1 Accuracy on long single track legs.

5.1.1 Overall System Accuracy. Blue Silk/G.P.I.4a/G4B system errors were obtained on all straight legs where the equipment remained serviceable between two positive fixes. Calculations of all the system errors given in Tables 1 and 2 were corrected for the change in length of a minute of latitude with change of latitude and also for the effect of aircraft altitude. For normal maritime operations the error due to the aircraft's height is negligible and may generally be ignored. For example, even at 5,000' the error induced in a flight of 1,000 n.ms. would only be of the order of ¼ n.m. In addition, the errors for flight 10 were corrected for G.P.I. resolution error obtained from Table 4. The errors for all the legs calculated over both land and sea are given at Table 1 below. The mean values given in this table are therefore the figures that are likely to be encountered in varying conditions over both land and sea.

Table 1

Blue Silk/G.P.I.4a/G4B System Errors - Straight Legs - All Flights.

Flight No.	Leg	Dist. N.M.	Type of fixing Aid Used.	Along Track Error %	Across Track Error °	Radial Error %
1	Start Pt. - Porto Santo	1170	Decca & Visual	-1.65	0.54S	1.89
	Porto Santo - Gibraltar	557	Visual	-0.19	0.80P	1.41
3	El Adem - Ft. Leclerc	574	Visual	-0.01	0.57P	1.00
	Ft. Leclerc - El Adem	574	Visual	-0.21	0.10P	0.28
4	El Adem - Marsala	670	Visual	-1.35	1.60P	3.09
	Marsala - Gibraltar	860	Visual	-1.02	0.92P	1.87
5	Gibraltar - Porto Santo	557	Visual & A.S.V.	-1.85	0.58S	2.10
	Porto Santo - 4147N 1006W	600	A.S.V. & Astro	+3.00	0.90P	3.39
6	C.Carvoeiro - Start Pt.	697	Visual & Decca	+0.53	1.33P	2.38
7	Inishtrahull - Keflavik	692	Decca & Visual	-1.93	0.51P	2.12
10	Boscombe Down Herdla	612	Decca & Visual	+0.95	0.09P	0.96
	Herdla - Boscombe Down	610	Visual & Decca	+1.22	0.63S	1.64
	Mean Along Track Error All Runs 50% Scatter with respect of Mean			-0.21% ±1.00%		
	Mean Across Track Error all Runs 50% Scatter with respect to the Mean				0.42°P ±0.50°	
	Mean Radial Error All Runs 50% Scatter with respect to the mean				1.84% ±0.73%	

5.1.2 System Accuracy - Sea. In order to derive figures for system accuracy when flying solely over the sea, the errors for legs entirely over the sea and those parts of other legs which were over the sea have been segregated and are shown in Table 2. The mean radial error for these long flights, of 2.18%, compares with the figure of 2.10% obtained during Phase 1.

Table 2.

Blue Silk/G.P.I.4a/G4B System Errors - Straight Legs - Sea Only.

Flight No.	Leg	Dist. N.M.	Type of Fixing Aid Used.	Along Track Error %	Across Track Error °	Radial Error %
1	Start Pt. - Porto Santo	1170	Decca & Visual	-1.65	0.54S	1.89
	Porto Santo Gibraltar	557	Visual	-0.19	0.80P	1.41
4	3254N 2202E - Marsala	555	Visual	-1.48	1.80P	3.47
	Marsala - Gibraltar	860	Visual	-1.02	0.92P	1.87
5	Gibraltar - Porto Santo	557	Visual & A.S.V.	-1.85	0.58S	2.10
	Porto Santo - 4147N 1006W	600	A.S.V. & Astro	+3.00	0.90P	3.39
6	C. Caroeveior - Start P.	697	Visual & Decca	+0.53	1.33P	2.38
7	Inishtrahull - Keflavik	692	Decca & Visual	-1.93	0.51P	2.12
10	5347N 0002W - Herdla	446	Decca & Visual	+1.06	0.36P	1.22
	Herdla - 5339N 0010E	445	Visual & Decca	+1.34	0.83S	1.98
	Mean Along Track Error Sea			-0.22%		
	50% Scatter with respect to the Mean			±1.12%		
	Mean Across Track Error Sea			0.47P		
	50% Scatter with respect to the Mean			±0.59°		
	Mean Radial Error Sea			2.18%		
	50% Scatter with respect to the Mean			±0.62%		

5.1.3 System Accuracy - Land. The only long legs carried out over land during Phase II of the trial were those over the desert in Flight No. 3. The accuracy figures for these legs are included in table 1 and it will be seen that the radial errors of 1.00% and 0.28% are very much smaller than the mean radial error for the accuracy runs over land in Phase 1 of the trial.

5.2 Accuracy during Tactical Search Patterns. Three flights were carried out to determine the accuracy of the Blue Silk/G.P.I. 4a/G4B system while engaged in tactical manoeuvres. For this purpose, the selected patrol was a creeping line ahead. The accuracy is given in Table 3 in terms of radial error. No corrections have been made for the variation in length of a minute of latitude or for the height of the aircraft as these can be considered to be negligible for a flight of this nature. The radial errors quoted do, of course, include any error induced into the system during the turn at the end of each leg of the patrol.

Table 3.

Blue Silk/G.P.I. 4a/G4B System Errors - Tactical Search Patterns.

Sortie No.	Dist. Flown N.M.	Fixing Used	Radial Error %
11	269	Decca	3.38
12	383	Decca	2.14
13	409	Decca	2.03

5.3 Narrative of Flights. Fig. 5 shows the routes followed during the Phase II flying which are listed at Appendix A. Comments on the individual flights are contained in the following paragraphs.

5.3.1 Flight No. 1 (Boscombe Down - Madeira - Gibraltar). This flight was carried out entirely at 2000' and mainly at night, and was assessed for accuracy on two legs between Start Point (5013N 0338W) and Porto Santo in Madeira (3303N 1617W), and Port Santo and Tarifa Point (3600N 0537W). Blue Silk was serviceable and remained locked on for the whole flight, giving 5 volts A.G.C. for the majority of the time. The wind encountered throughout this flight was light but predominantly westerly.

5.3.2 Flight No. 2 (Gibraltar - Marsala - El Adem). This flight was carried out at 3000' over low sea states. Although the sea state was 3 on leaving Gibraltar, it soon dropped and remained about 1-2 for the remainder of the flight. Blue Silk remained locked on throughout the flight and gave A.G.C. volts of 4.5-5. However, a fault in the discriminator back plate developed very shortly after leaving Gibraltar which had the effect of transmitting a ground speed to the G.P.I. which was too low. It was therefore impossible to determine a realistic system error on this flight. The Blue Silk groundspeed and drift indications and the distance counters were unaffected by the fault and were used navigationally. The implications of this fault are fully discussed in para. 9.1.4.

5.3.3 Flight No. 3 (El Adem - Ft. Leclerc - El Adem.) This flight was carried out in order to check the performance of Blue Silk over the desert. The outbound leg from El Adem to Ft. Leclerc (2701N 1427E) was flown at heights between 500' and 1000' A.G.L. The return leg was flown at 7,000'. The indications of performance were good throughout with about 5 volts A.G.C. at 1,000' dropping to a minimum of 4.3v at 500'. At 7,000' the A.G.C. voltage varied between 4.4 and 4.8v. A maximum of 2 neons was observed during the flight and the red light behaved satisfactorily. The G.P.I.4a was used with Along and Across Track presentation and reference to Table 1 shows that the system accuracy was of a high order.

5.3.4 Flight No. 4 (El Adem - Marsala - Gibraltar). Both legs of this flight were carried out at 1,000' and were assessed for accuracy between El Adem and Marsala and between Marsala and Gibraltar. Between the coast of Cyrenaica and Marsala the sea state increased from 2-3 to 4-5 approaching the coast of Sicily. Blue Silk remained serviceable and locked on throughout this leg. After leaving Sicily, the sea state gradually dropped and was down to state 1 when approaching Gibraltar. The equipment remained serviceable but unlocked on two occasions when near Gibraltar over the sea state 1. The equipment was not switched to Memory because it was desired to check the performance continuously, but the groundspeed and drift needles were maintained in their approximately correct positions by use of the inching controls. The equipment was actually unlocked for two periods of under 5 minutes but was rather sluggish for half an hour with A.G.C. volts down to 2.4 and several neons flashing. The red light was on during this time.

5.3.5 Flight No. 5 (Gibraltar - Porto Santo - 4147N 1006W - Lisbon) The original routing of this flight was to Boscombe Down, but unserviceability of the aircraft necessitated a diversion to Lisbon from position 4147N 1006W. An astro fix was obtained just before turning back to Lisbon and the errors for the second leg have been calculated with reference to this. It will be seen from table 2 that the errors for the second leg are unduly large. This may be partially due to sea movement caused by the strong headwind encountered of 30 - 40 knots (see also para. 7) but the possibility of errors in the Astro fix must also be accepted. However, a comparison between the radial error for this leg of 3.39% and the radial error of 3% obtained at Lisbon indicates that the error in the astro fix was not unduly great. The first leg was flown at 2,000' but cloud at this height made it necessary to climb to 5,000' just before reaching Port Santo and the remainder of the flight was carried out at this height. Blue Silk remained serviceable throughout the flight and was giving 5v. A.G.C. with only one neon flashing, except for a period of 5 minutes while flying over a calm sea shortly after leaving Gibraltar when the A.G.C. volts dropped to 4.2v and the red light was on with about 6 neons flashing.

5.3.6 Flight No. 6 (Lisbon - Boscombe Down). This flight was carried out at 7,000' and Blue Silk remained serviceable throughout. Accuracy figures were obtained between Cape Carvoeiro (3921N 0924W) and Start Point (5013N 0338W). The system error was rather large for this leg, but, as there was a fairly steady surface wind of approximately 30K from about 45° on the Port bow, the error may include a large proportion attributable to sea movement (See also para. 7.).

5.3.7 Flight No. 7 (Boscombe Down - Keflavik). The Blue Silk equipment was unserviceable for the first part of this flight but, after rectification, was serviceable for the remainder of the flight between Inishtrahull (5627N 0714W) and Keflavik which was carried out at 2,000'. The A.G.C. volts were variable between 3 and 5 in spite of sea states between 3 & 7.

5.3.8 Flight No. 8 (Keflavik - 6500N 2600W - 7010N 2206W - 7005N 2830W. Keflavik). Owing to weather conditions this flight was routed on a dog-leg to avoid the mountains of N. Iceland. Over the Denmark Strait winds of up to 60 knots were encountered with sea state 7-9 and the Blue Silk performed satisfactorily. Approaching the pack ice however the wind dropped and the sea state became 2-3 giving A.G.C. volts of 4-4.5. On crossing from sea to ice, the A.G.C. voltage dropped slightly to 3.3 - 3.5 volts. Performance of Blue Silk was checked in turns over both pack ice and the ice cap of Greenland (see para. 6.5). Unlocking occurred when crossing the mountains at the edge of the Greenland escarpment both inbound and outbound and this is discussed in para. 6.6. When flying over the Denmark Strait on the return flight, the Transmitter/Receiver unit failed and was replaced by the spare. No further unserviceability occurred during the flight.

5.3.9 Flight No. 9 (Keflavik - Boscombe Down.) Unserviceability occurred shortly after take-off and was found to be due to an intermittent contact in the discriminator back plate. This was rectified by tightening the fixing nuts. A further fault necessitated changing the amplifier unit but the performance of Blue Silk continued to be poor, due to overheating in the Transmitter/Receiver unit, until the cover was removed (see Appendix 'B', para. 5.6.(b)). Because of these faults it was impossible to obtain any accuracy figures for this flight.

5.3.10 Flight No. 10 (Boscombe Down - Hordla - Boscombe Down). The object of this flight was to derive the accuracy of the Blue Silk/G.P.I.4a/G4B System after certain known errors had been allowed for or eliminated. The equipment was tested on the ground to determine the value of the error in Blue Silk transmission and G.P.I. resolution, when the inputs to the G.P.I. were approximately those to be expected during the sortie. The results, which are given in Table 4 below, were used by the navigator during flight to modify G.P.I. position. The Blue Silk

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was re-adjusted on the ground with the object of producing an over-reading of 1% in the measurement of distance flown over land. This adjustment was made in order to compensate for an anticipated spectrum distortion error of -1% over average sea states (phase 1, sub. para. 15.2.2. refers).
Compass deviations found during the air calibration were used for this flight, which was carried out at 1000' - 1500'. The sea state varied from 5-6 off the English coast to 1 off Norway and the A.G.C. volts dropped from 5- 2.8v during the outward flight but this does not appear to have affected the accuracy of the equipment. On the homeward flight the equipment was unlocked for about 15 minutes on leaving the Norwegian coast, and later the A.G.C. volts never rose above 3 although there was no undue spread of neons.

Table 4 - G.P.I. Resolution Accuracy prior to Flight 10

Run	Dist n.m.	Hdg.	Drift	Track	Along Track Error		Across Track Error	
					Dist	%	Dist n.m.	Degrees
1	300	016	5S	021	Nil	Nil	1.4P	.27P
2	300	206	5P	201	Nil	Nil	0 .8S	.13S
3	300	016	5S	021	Nil	Nil	1.4P	.27P
4	300	206	5P	201	Nil	Nil	0.7S	.15S

5.3.11 Flight No. 11 (Creeping Line Ahead Patrol). This flight was carried out to simulate a creeping line ahead patrol with 50 mile legs at 1000' above sea level. The sea state was 2-3 and the Blue Silk efficiency was low with A.G.C. volts down to 2-3. The red light came on in turns several times and on one occasion the equipment unlocked in a turn with 30° bank. After the conclusion of the patrol, it was found that the equipment would not remain locked below 800'. Subsequently, a fault was found in the T.R. cells and this is considered to be the cause of poor performance and accuracy on this flight.

5.3.12 Flight No. 12 (Creeping Line Ahead Patrol). This and the following flight were also carried out to simulate a creeping line ahead patrol but with 75 mile legs. The height for this flight was 1000'. Although the sea state was 3-4, the A.G.C. volts dropped from 5.2 to 2 during the patrol with an average of 2 neons showing. The red light remained off. After the patrol was finished the cover of the TR unit was removed and the A.G.C. volts returned to 5.

5.3.13 Flight No. 13 (Creeping line ahead patrol). This flight was carried out in the height band 250' - 350' in order to determine the performance and accuracy at low altitudes. The sea state was 5-6. After flying for 1 hour, the A.G.C. volts had dropped from 4.6 to 2. Once again, after removing the cover of the TR Unit, the A.G.C. volts rose to normal. At this height the red light was flashing on and off at irregular intervals.

5.4 Accuracy During Turns. A knowledge of the errors likely to accrue in the system during turns is of importance in maritime operations owing to the large number of turns which may be made in the course of patrols and searches, and it was therefore intended to investigate the magnitude of these errors, but this proved impossible when the trial was prematurely terminated due to major unserviceability of the aircraft. However, the three tactical flights discussed in paras. 5.3.11 - 5.3.13 each include eight turns of approximately 90°. Ground analysis of the fixes and G.P.I. positions recorded at regular intervals during each flight did not disclose any error which could be ascribed to the turn, but it is unlikely that any single turn would produce an error large enough to be

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detected in this way. The fact that the total radial errors given in table 3 are not unduly large is not in itself however, an indication that turn errors can always be ignored. It is probable that the effects are to a large extent self-cancelling in patrols of this nature where alternate pairs of turns take place in opposite direction, but if different patterns were flown, the total sum of the turn errors might well become significant.

6. Performance of Blue Silk over various Reflecting Surfaces

6.1 The Requirement. Joint Naval/Air Staff Requirement No. AW.260 states that Blue Silk should be capable of operating under varying conditions in all parts of the world. In order to check this, the equipment was flown over the following types of surface during the course of the trial:-

(a) Rough and Calm Sea
(b) Temperate Land.
(c) Desert
(d) Ice and Snow
(e) Mountains.

Details of the performance are given below.

6.2 Rough and Calm Sea

6.2.1 Owing to the maritime use of Blue Silk, great emphasis was placed on its performance, both straight and level and in turns, at varying altitudes over various sea conditions. Experience with the equipment under test showed that the performance could change to some extent from day to day due to the varying efficiency of the equipment. It is therefore impossible to give any hard and fast rule about the performance of Blue Silk over the sea and the figures given must be accepted as those for a set working at average efficiency.

6.2.2 In straight and level flight, Blue Silk operated satisfactorily at all altitudes tested from 5,000' down to 300' provided the sea was state 2 or more. A minimum of 200' was reached on one occasion over sea state 2 and on another occasion over sea state 7. Successful operation was also obtained in one instance over sea state 5-6 (with a wind speed of 27 knots) down to 100' whilst flying into wind and sea, but this limit was raised to 180' when the aircraft was turned across wind. On only one occasion was Blue Silk operated over sea state 1. The performance was marginal and two short periods of unlocking occurred. The aircraft's altitude was 1000 feet A.S.L.

6.2.3 No turns were carried out over sea state 1, but with the sea state 2 or more, the equipment normally functioned satisfactorily in turns of up to 30° bank down to 300' although at times the movement of the drift and ground speed needles was sluggish.

6.2.4 The balance of the set under test was such that the drift and ground speed needles tended to remain at their last reading when unlocking occurred. The only positive test that unlocking had occurred was to deflect the needles and see if they returned to their former readings, although an indication is normally given by the behaviour of the red light, A.G.C. voltage, and neon spectrum.

6.2.5 When flying below the height at which the Blue Silk will normally remain locked (e.g. very low level searches and attacks), the equipment should be switched to "Memory" and the most accurate known values of drift and groundspeed set on the indicator with the inching controls. The system will then operate satisfactorily within the limits of accuracy of the input information. The same procedure may be adopted if the Blue Silk becomes unserviceable provided that the Signal/Memory switch, inching controls and transmission system still operate satisfactorily.

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6.3 Temperate Land. Very little flying was carried out over temperate land during this phase of the trial, since a full evaluation had already been made in Phase 1.

6.4 Desert. One flight (No. 3) was carried out over the desert between El Adem and Fort Leclerc, the outward flight being at heights of 1,000' and below and the return flight at 7000'. The equipment functioned quite satisfactorily at all heights from 7,000' down to the lowest tested (500 ft. a.g.l.)

6.5 Snow and Ice. The performance of the equipment was tested over pack ice and over the ice-cap of Greenland on sortie No. 8. The equipment performed satisfactorily over both these reflecting surfaces, although a slight drop in A.G.C. volts from 4-4.5 to 3.3-3.5 was noticed after passing from open sea to pack ice. At about 2000' over both forms of ice the A.G.C. gave 3-3½ volts when flying straight and level. The equipment performed satisfactorily in turns of up to 30° bank, but at angles of bank greater than this, the red light came on with a full neon spread and the equipment unlocked.

6.6 Mountains. When crossing the escarpment of the Greenland ice-cap in the vicinity of Scoresby Sound, the Blue Silk equipment became unlocked at both straight and level and climbing conditions. Once over the comparatively smooth snow covered ice-cap however, the equipment locked on and behaved normally until once again crossing the escarpment on the return journey, when it again became unlocked until over the sea. These observations tend to show that the equipment will not work satisfactorily when flying over mountains with near vertical sides and steep ravines. However, it must be remembered that the mountains of the Greenland escarpment are exceptional in this respect and it is probable that the equipment will not unlock over mountains that are less steep. It was hoped to investigate this phenomenon more thoroughly over other mountain ranges, but this was not possible.

7. Errors due to Sea Movement

7.1 Effect of Sea Movement on Blue Silk. Blue Silk measures the relative velocity between the aircraft and the reflecting surface. If the reflecting surface moves, an error will be induced in Blue Silk drift and groundspeed which is equal to the velocity of the reflecting surface. When flying over the sea, therefore, an error will be induced into the equipment which is equal to the movement of that part of the sea which is reflecting the Blue Silk transmissions. It is not known precisely how far the pulses of radio energy transmitted by Blue Silk will penetrate (if at all) into the sea before being reflected, but it has been suggested that the Doppler signal is reflected from wave crests and other small discontinuities in the water surface.

7.2 Causes of Sea Movement. Factors affecting the movement of the sea are many, but the important ones are as follows:-

(a) Surface wind.
(b) Rotation of the earth.
(c) Differences of temperature.
(d) Configuration of the sea bed.
(e) Tidal effects.
(f) Differences in salinity.

The relation between these factors is extremely complex, but if the suggestion in para. 7.1 is correct then it is obvious that the surface wind is the predominant factor which must be considered in any investigation of Blue Silk Errors due to sea movement. The precise relationship is unlikely to be constant, but some authorities have suggested[3] that the error in Doppler equipments due to sea movement is between one sixth and one seventh of the surface wind speed while others quote a figure of one tenth.

/7.3....

7.3 Investigation of Relationship between Surface Wind Velocity and Blue Silk Error when flying over the Sea.

7.3.1 The results obtained during the trial previously quoted in tables 2 and 3, were subjected to further analysis in an endeavour to establish a working relationship between surface wind velocity and vector error due to sea movement which, while unlikely to be precise, might form the basis of a practical means of system error correction during flight. In order to do this, it was necessary to obtain a figure for the overall system error of the Blue Silk/G.P.I.4a/G4B system for flights over the sea with a steady wind velocity, and extract from this the system error due to the causes other than sea movement. System error in Phase II was normally measured along one straight track, and in these circumstances it is not possible subsequently to detect the components making up the final vector error. Where a flight consisting of several pairs of reciprocal tracks took place however, it was thought reasonable to assume that systematic errors in drift, groundspeed and compass errors of a constant nature would tend to be self-cancelling, the final vector system error being due in the main to sea movement. Three flights of this nature were carried out (Nos. 11, 12 and 13) which were in fact simulated creeping line ahead patrols. They were not ideal for the analysis of errors caused by sea movement since they included errors induced by the turns and the progression along the line of creep. However, it is interesting to examine the radial errors for these flights and compare them with the surface wind velocities which were fairly constant in both speed and direction. These figures are given in table 5 below.

Table 5

Comparison of Radial Errors and Surface W/V's for Creeping Line Ahead Patrols

1	2	3	4	5	6	7
Flight	Total Radial Error		Mean Radial Error n.m./hr.	Mean Surface W/V		Column 4 / Column 6
	Degrees	Dist.n.m.		Degrees	Kts.	
11	058	9.1	5.2	070	15	.35
12	244	8.2	3.5	240	15	.23
13	261	8.3	3.4	259	21	.16

7.3.2 An examination of Table 5 shows that there is a very marked similarity between the direction of the radial error and the direction of the surface wind. The relationship between the speeds given as a ratio in column ~~six~~ 7 is not so clear and varies between 0.16 and 0.35. From these figures it would appear that the ratio of sea movement to surface wind speed is roughly ¼. This does not agree with the opinion of the authorities quoted in para. 7.2 and since it is based on the evidence of only three flights, it should be treated with caution. However, it is interesting to apply this figure to the system error of other flights during Phase II of the trial for which accuracy figures are available. This has been done and the two sets of figures are shown in Table 6 below.

Table 6

Comparison between Observed System Errors and the same errors corrected for Sea Movement

Leg	Observed system Errors			System Errors corrected		
	Along %	Across Degrees	Radial %	Along %	Across Degrees	Radial %
Porto Santo - Gibraltar	-0.19	0.80P	1.41	-1.15	0.07P	1.16
Gibraltar - Porto Santo	-1.85	0.58S	2.10	-0.29	0.15S	0.39
Porto Santo - 4147N 1006W	+3.00	0.90P	3.39	+0.08	1.43P	2.50
Lisbon - Start Point	+0.53	1.33P	2.38	-0.66	0.10S	0.68
Inistrahull - Keflavik	-1.93	0.51P	2.12	-1.17	0.13S	1.19
Boscombe Down - Herdla	+0.95	0.90P	0.96	+0.59	0.74S	1.42
Herdla - Boscombe Down	+1.22	0.63S	1.64	+0.07	0.30S	0.53
Mean	+0.25	0.35P	2.00	-0.36	0.01P	1.12
50% Scatter about the mean	±1.18	±0.51	±0.65	±0.44	±0.46	±0.60

7.3.3 In Table 6 above, flights where the mean surface wind speed was less than 10 knots have been omitted as it is considered that at speeds less than this figure, the wind may cease to be the predominant factor in determining the speed and direction of sea movement. In cases where there was a marked change in surface wind during the flight, a mean equivalent wind has been used. The correction for sea movement has only been applied for the period of the flight during which the aircraft was actually over the sea.

7.3.4 An examination of Table 6 shows that out of the seven legs selected, six show a reduction of radial error when corrected for sea movement at the rate of ¼ x wind speed. The evidence provided by seven results to support a theory based on three further results is certainly inconclusive, but it may well be that with further data, it would be possible to markedly reduce the system error of the Blue Silk/G.P.I.4a/G4B combination by the application of "sea movement correction" based on a knowledge of the surface wind and its characteristics (e.g. general tendency and length of time that it has been blowing).

8. Pilot's Track Indicator

8.1 Installation. At the 33rd Programme Conference of the Experimental Navigation Division of A. & A.E.E. it was requested that a further assessment of the Pilot's Track Indicator be carried out in conjunction with Blue Silk/G.P.I.4a. Such an indicator (a standard D.R.C. repeater) was therefore fitted on top of the cockpit coaming on the port side of the V.H.F. control box and angled so as to be easily seen by the first pilot. A photograph of this installation is shown at Fig. 2.

8.2 Evaluation. The track indicator was used as a steering datum on several flights under varying conditions. In its present form it was found that the indications were not stable but tended to oscillate about a mean position, following the oscillations of the Blue Silk drift needle. This necessitated the pilot having to steer a mean track and it was found that this was far less easy than steering from the G4B compass. Although it was found that the use of the track indicator did save the navigator a slight amount of work, it was hardly of worth while value on long transit flights. However, the indicator was also used on the tactical

/flights....

flights involving creeping line ahead patrols, and it was considered that for flights of this nature, when frequent track changes are necessary, it is of more value. In order to be an acceptable instrument it is considered that the oscillations of the track indicator needle would need to be damped to give a reasonably steady reading.

9. Serviceability of the Tested Equipment

9.1 Blue Silk

9.1.1 In 108 hours and 20 minutes flying time, and 49 hours and 45 minutes ground running time, the Blue Silk was found to be unserviceable on 12 occasions, of which 5 occurred in the air. A total of 21 faults was remedied. This serviceability compares favourably with that experienced in Phase I of the trial when the equipment was found to be unserviceable on 12 occasions in 91¼ flying hours and 80½ ground running hours. It should be noted that apart from spare units which were brought into use at various times on the overseas flights, the set used was the same as that used throughout Phase I of the trial, and had therefore been operating for a grand total of 329 hours and 50 minutes ground and air whilst at Boscombe Down.

9.1.2 Daily routine ground inspections and rectification were the responsibility of Radio Division, A. & A.E.E., and these were carried out by the same two N.C.O's as during the Phase I. One N.C.O. flew on all trials sorties in order that faults could be located and where possible rectified during flight.

9.1.3 A report on serviceability and servicing of Blue Silk during the trial has been prepared by Radio Division A. & A.E.E. and is given at Appendix 'B'. It covers the technical aspects of servicing, a detailed analysis of faults, an assessment of reliability and conclusions and recommendations of a technical nature. Aspects of serviceability which affect the aircrew operator are discussed below.

9.1.4 While flying from Gibraltar to El Adem on flight No. 2 independent fixes showed that the G.P.I. position was incorrect, the error being in a direction along track and amounting to approximately 10% of distance flown. Blue Silk appeared to be indicating the correct ground speed and the distance gone counters showed a value agreeing within reasonable limits with the independant fix. The cause of the error was eventually found to be a faulty connection in the back plate of the tracking unit assembly in the circuit from the ground speed "M" type transmitter to the G.P.I. (See Appendix B). This fault emphasises the need for the aircrews to check the position shown on the G.P.I. with the information on the Blue Silk Indicators.

9.1.5 On one occasion, the 100 amp. fuse was blown when the equipment was switched on before take-off. This is believed to have been due to the inadvertant switching on of the Blue Silk at the same time as the aircraft generators, thus causing an abnormal surge of power through the circuit. It is therefore emphasised that it is important to ensure that the Blue Silk is not switched on until the generators are known to be in operation.

9.2 Interference. No interference was noticed between the Blue Silk and any of the radio/radar installations in the trials aircraft. As in Phase I of the trial, it was hoped to determine if there was any mutual interference between two Blue Silk equipped aircraft flying in formation, but this was not possible owing to the repeated unserviceability of the Blue Silk/Gannet combination.

9.3 Serviceability of the G.P.I. 4a. The G.P.I. 4a remained fully serviceable throughout the trial in all its functions. This is especially commendable as it was the same instrument as used during Phase I of the trial, and had been used for a total of 195 hours.

/10.......

10. Performance of the G.P.I.4a.

10.1 Accuracy. During phase I of the trial the resolution accuracy of the G.P.I.4a in the air was thoroughly tested on "Grid" presentation, and it was stated that tests carried out by R.A.E. indicated that its accuracy should not differ greatly when other forms of presentation are used. During Phase II, the G.P.I. was operated mainly on "Along and Across" and Latitude and Longitude presentation, but as the auto-observer was not used in this phase of the trial it was not possible to determine the G.P.I.4a resolution errors in flight. The ground resolution runs were therefore carried out with Latitude and Longitude presentation, using inputs with the Blue Silk on "Memory". These runs confirmed the results obtained in Phase I. Ground resolution runs using "Along and Across Track" presentation, the results of which are shown in Table 4, had already been carried out prior to flight 10.

10.2 Slipping of the Secant Gear. In addition to those mentioned above, ground resolution runs were also carried out to determine the latitude at which slipping of the secant gear became excessive. This was found to be 79°N.

10.3 Presentation. Some difficulty was experienced in reading the counters (especially at night) due to their being recessed into the face of the instrument, unless read from a position normal to the windows. This point must be borne in mind when deciding the operational positioning of the indicator.

11. Conclusion and Recommendations

11.1 Conclusions

11.1.1 Handling and Operation of the Equipment. The equipment was used in a realistic manner by a number of operators. No difficulty was found in handling and operation. However, experience with handling the G.P.I. 4a in Phase II confirmed the comments on presentation given in the Phase I report. Blue Silk proved simple to use and no difficulty was experienced with the operating drills which were the same as those outlined in Appendix 'G' to the Phase I report. In addition, the modifications to the drift and ground speed indicator recommended in the Phase I report would facilitate reading and reduce the likelihood of mis-interpretation.

11.1.2 Performance. The performance of Blue Silk was tested over varying terrains in a wide range of conditions. It was found that it operates satisfactorily over land and ice except that unlocking may occur when crossing particularly steep mountains. Over the sea the equipment generally functions satisfactorily both straight and level and in turns of up to 30 degrees of bank and down to 300 feet providing the sea is state 2 or more. Over sea state 1 however, the equipment unlocked on two occasions in straight and level flight at 1,000 feet.

11.1.3 System Accuracy - Blue Silk/G.P.I.4a/G4B. The mean radial error for all long straight legs in Phase II was approximately 1.8 n.ms. for every 100 n.ms. flown. For those flights entirely over the sea the mean radial error was approximately 2.2 n.ms. for every 100 n.ms. flown which compared very closely with the figure of 2.1 n.ms. for corresponding flights in Phase I. For the only two legs flown over the land, the radial errors were 1.0% and 0.3% approximately. Efforts were made to determine the correlation between system error and sea movement due to wind and this appeared to be about ½ wind speed with the data available. Applying this correction reduced the radial error in six out of the seven cases examined, and reduced the mean radial error for these legs from 2.00% to 1.12%.

/11.1.4......

11.1.4 Serviceability. The serviceability of Blue Silk was very similar to that experienced in Phase I of the trial in spite of the increased operating hours with the same set. The G.P.I.4a continued to operate faultlessly.

11.1.5 Track Indicator. The Pilot's Track Indicator was not found to be of sufficient value to warrant introduction into Service use in its present form.

11.2 Recommendations. The recommendations in the Phase I report are re-affirmed and in addition it is considered that further work should be carried out to determine the effect of sea movement due to wind, and how it may be allowed for in flight.

Acknowledgements

The Establishment wishes to place on record its appreciation of the cooperation of Headquarters Coastal Command, R.R.E., and R.A.E.

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/Appendix 'A'....

Appendix 'A' to Report No.
AAEE/Tech/122/Nav. Part II.

List of flights carried out during Phase II of Blue Silk/G.P.I. 4a trial

Flight No.	Route	G.P.I. Presentation
1	Boscombe Down - Madeira - Gibraltar	Lat. & Long.
2	Gibraltar - Marsala - El Adem	Lat. & Long.
3	El Adem - Ft. Leclerc - El Adem	Along & Across Track
4	El Adem - Marsala - Gibraltar	Lat. & Long.
5	Gibraltar - Madeira - Lisbon	Lat. & Long.
6	Lisbon - Boscombe Down.	Lat. & Long.
7	Boscombe Down - Keflavik	Along & Across Track
8	Keflavik - 65°N 26W - 7010N 2206W - 7005N 2830W - Keflavik	Grid
9	Keflavik - Boscombe Down	Along & Across Track
10	Boscombe Down - Herdla - Boscombe Down	Along & Across Track
11	Creeping Line Ahead Patrol	Lat. & Long.
12	Creeping Line Ahead Patrol	Lat. & Long.
13	Creeping Line Ahead Patrol	Lat. & Long.

/Appendix 'B'.....

Appendix 'B' to Report No.
AAEE/Tech/122/Nav. Part II.

REPORT ON BLUE SILK SERVICEABILITY DURING PHASE II TRIAL - 20th AUGUST - 12th DECEMBER, 1955

prepared by

Radio Division, A. & A.E.E.

1. Introduction

Phase two of Acceptance and Service Trials were carried out at Boscombe Down during the period 20th August to 12th December, 1955.

2. Equipment Employed

Air Ministry had allocated No. 3 Development Model for A. & A.E.E. Trials. Sets of spare units were used as backing for the overseas flights only. These spare units were loaned by R.R.E. Malvern for these periods. Spare Units carried during Flight to El Adem were:-

(a)	T.R. Unit	No. 6 Development Model.
(b)	E.H.T. Power Unit	No. 1 Development Model.
(c)	Tracking Unit Disc. Section	No. 1 Development Model. No. 1 Development Model.
(d)	Tracking Unit Amp. Section	No. 1 Development Model. No. 1 Development Model.
(e)	Indicator Unit.	No. 1 Development Model.

Due to the failure of No. 3 Tracking Units, No. 1 Tracking Units were used.

Spare Units carried during Flight to Keflavik.

(a)	T.R. Unit	No. 6 Development Model.
(b)	E.H.T. Power Unit.	No. 5 Development Model.
(c)	Tracking Unit Disc. Section	No. 5 Development Model. No. 5 Development Model.
(d)	Tracking Unit Amp. Section	No. 5 Development Model. No. 5 Development Model.

Due to the failure of No. 3 T.R. Unit and No. 3 Tracking Units, No. 6 T.R. Unit and No. 5 Development Model Tracking Units were used.

3. Servicing Policy

Periodic Servicing of the equipment was carried out during the Trials by the servicing party of A. & A.E.E. Radio Trials Division, trained for that purpose.

A record of man hours expended in servicing is tabulated in paragraph 4.

4. Serviceability

4.1 Periods of serviceability of the equipment installed in the aircraft are divided into the following periods:-

Date	Air Failure	Flying Hours	Total Air and Ground Running Time Since last air Failure
20.8.55.	Start of Phase Two trials	-	-
8.9.55.	Failure of No. 3 Tracking Unit	26.35	37.35
1.11.55.	Failure of No. 3 Tracking Unit	38.20	48.50
3.11.55.	Failure of No. 3 T.R. Units	09.00	15.30
4.11.55.	Failure of No. 3 Tracking Unit	(1.50 (4.10	1.50 4.10
29.11.55.	Failure of No. 3 Tracking Unit	35.20	29.50
	Average time between Air Failures	22.30	

4.2 On three occasions during flight, due to the performance of the equipment falling off, the cover to the T.R. Unit was removed and the set recovered.

4.3 Time expended on servicing

Normal periodic inspections	13.45 hours.
Rectification	36.00 hours.
	49.45 hours.

4.4 A complete list of failures, ground and air running time is attached.

5. Analysis of Faults

Total Faults	22
(a) Aerial Unit Faults	Nil
(b) Indicator Faults	Nil
(c) T.R. Unit Faults	7
(d) Tracking Unit Faults	6
(e) Power Unit Faults	2
(f) Mounting Assembly Faults	2
(g) Other Faults	4
(h) Power Supply Faults	1

5.1 T.R. Unit

(a) The seven faults in the T.R. Unit were:-

2 T.R. Cells

Failures were confined to one T.R. cell.

The auxiliary keep alive probe was found to be short circuited when tested in the set, on removal and subsequent checking, it eventually recovered but was not re-installed in the equipment.

No fault was found in the other T.R. cell, but it was replaced by a new one, in order to keep both new T.R. cells together.

(b) 2 CV 404's.

In both cases the cathodes were stripped.

(c) CV. 425.

Owing to failure of the T.R. Unit it was considered worth checking this diode as a possible weak component. The diode was changed but proved subsequently not to have caused the failure.

/(d)....

(d) C.40

This is a variable condenser, which controls the position of the suppression pulse and hence the efficiency of the set at its minimum working height.

The position of C.40 was altered to its optimum position.

(e) CV. 4036.

The cathode of this valve was found to be stripped.

5.2 Tracking Units (Discriminator and Amplifier sections)

(a) V.30 CV. 468

This valve was found to have an intermittent grid connection.

(b) V.4 CV.465.

This valve was found to have a grid to cathode short.

(c) V.7 CV. 469
(d) V.21 CV. 469
(e) V.18 CV. 469
(f) V.13 CV. 469

These valves had cathode to heater shorts

5.3 Power Unit Faults

(a) The two failures in the Power Unit were:-

2 CV. 4001's.

In both cases the cathodes of these valves were stripped.

5.4 Power Supply Faults

(a) 100 Amp. Fuse (Z.590129)

This fuse was blown when the equipment was switched on prior to intended take-off.

The equipment was switched on simultaneously with the aircraft generators, and it is probably that the initial surge of voltage caused by the generators coming in combined with the normal high current starting of the Invertor 103 caused the fuse to be blown.

5.5 Mounting Assembly Faults

The two faults in the mounting assembly were:-

(a) The 'M' Type Transmission to the G.P.I. was incorrect due to faulty contact in S.R.W.

(b) Faulty pin connections in sockets W.Y & Z caused the set to unlock. It was found that some pins had been stretched open, thus not affording correct contact. On the replacement of these pins this fault did not recur.

5.6 Other Faults

(a) Cable N.A.

/Pin Y......

Pin Y on cable NA was found to be open circuit. This lead carried the video output to the test set, providing a wave-form on the test for setting up purposes. This video output lead is of screened uniway radio and is more vulnerable at the soldered connection than the other leads making up the cable.

(b) Heating in the T.R. Unit.

On three occasions on two different T.R. Units it was found that after a period of one hour or more the gain of the equipment would gradually decline. On removal of the cover of the T.R. Unit the set would recover and continue to work efficiently. On replacement of the cover after a short period the symptoms would return and the set would drop in performance.

It was later discovered that the modulator valve was not driving the magnetron at its full power.

The gradual decline of the modulator valve might have caused the magnetron to be pulsed at lower power when the T.R. Unit became heated, causing the gain of the receiver to drop.

5.7 Faults of Components

Out of 21 failures, 14 failures were due to components failures.

(a)	T.R. Cells CV . 2312	2
(b)	CV. 404	2
(c)	CV. 469	4
(d)	CV. 468	1
(e)	CV. 465	1
(f)	CV. 425	1
(g)	CV. 4036	1

6. Conclusions and Recommendations

6.1 It is concluded that:-

(a) That the diode CV. 469 was the weakest single component in the equipment.

(b) The valve which caused most other failures was the CV.404.

(c) The rate of failure of other components, was, for the complexity of the equipment, low.

6.2 It is recommended that:-

(a) The mounting assembly should be checked at intervals.

(b) The turning of the T.R. Unit should be carried out on suitable permanent echoes to eliminate the possibility of mistuning the Klystron.

(c) The setting up of the equipment should be carefully done to ensure the serviceability and accuracy of the equipment.

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COMPLETE LIST OF AIR AND GROUND FAILURES

Date	Valve Position	Valve No.	Unit No.	Fault	Symptoms	Cure	Failure Air or Ground	Flying Hours Between Air Failures (1)	Flying Hours Between Failures (2)	Ground Running Time (3)	Total running time since last failure	Running Total 171.45 hrs. from Phase I	Remarks
20/8	V1.V2	CV4001	Power Unit	150v.u/s.	No A.G.C. No Neons	V1.V2. replaced.	Ground	-	-	01.00	01.00	172.45	
22/8	V7.	CV2235 (CV4035)	T.R. Unit No. 3.	1KV u/s.	TX not firing.	V7. replaced.	Ground	-	00.55	06.00	06.55	179.40	
29/8	Pin Y on Cable NA	-	Cable NA from junction box to T.R.	Pin Y lead connection at T.R. open circuited.	No Video output to test set.	Pin Y connection made.	Ground	-	01.05	01.00	02.05	181.45	
8/9	-	-	Tracking Unit Disc.Sec.No.3.	Transmission of information of 'M' type TX.	G.P.I. out of step.	Unit changed	Air	26.35	24.35	03.00	27.35	209.20	Intermittent fault PLW and SKW.
11/9	V30	CV463	Tracking Unit Disc.Sect.1.	Intermittent grid connection.	Running down of	V30 replaced	Ground	-	07.00	00.30	07.30	216.50	
11/9	V4	CV465	" "	Grid to cathode short	needle, set not	V4 replaced	Ground						
11/9	V7	CV469	" "	Cathode to Heater short	locked on	V7 replaced	Ground						
11/9	V21	CV469	" "	Cathode/heater short.	Phonic wheel velodyne running at incorrect speed.	V21 replaced	Ground	-	-	-	-	-	Counter running at different speed than that indicated by ground speed needle.
1/11	-	-	Back plate assembly	Intermittent contact on pins 6,10,12 on SKZ Pin 5 on SKY.	Low A.G.C. volts. Set un-locking.	Pins replaced	Air	38.20	31.20	10.00	41.20	258.10	
3/11	100 amp. fuse	Z 590129	-	Fuse blown	No o/p from Inverter 103	Fuse replaced	Ground	-	04.10	01.15	05.25	263.35	No.115 v3 phase supply to equipment.
3/11	V1.V4.	CV404's	TR.Unit 3	Cathodes stripped.	Magnetron not firing.	V1 V4 replaced	Air	09.00	04.50	05.15	10.05	273.40	

/Contd....

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SECRET

COMPLETE LIST OF AIR AND GROUND FAILURES

Date	Valve Position	Valve No.	Unit No	Fault	Symptoms	Cure	Failure Air or Ground	Flying Hours Between Air Failures (1)	Flying Hours Between Failures (2)	Ground Running Time (3)	Total running time since last failure	Running Total 171.45 hrs. from Phase 1	Remarks
4/11	V.18	CV469	Tracking Unit Amp.Sec.3.	Cathode to Heater short.	Drift running to port.	V.18 replaced	Air	-	06.00	-	06.00	279.40	
22/11	V.13	CV469	Tracking Unit Amp.Sec.3.	Cathode heater short.	Ground speed running in.	V.13 replaced	Ground	-	05.00	06.30	11.30	291.10	
29/11	V.28	CV.2312	T.R.Unit 3.	Auxillary keep alive probe short cct.	Set not functioning at low altitude.	V.28 replaced	Air	19.20	14.20	03.30	17.50	309.00	
29/11	V.29	CV.2312	T.R.Unit 3	None found.	T.R. Cells checked.	V.29 replaced							V.29 replaced to keep new pair of T.R. cells together.
29/11	-	-	T.R.Unit 3	C.40 adjustment	Set not functioning at low altitude position of C.40 checked.	C.40 adjusted							
6/12	MR.6	CV.425	T.R.Unit (I.F.Strip)	Back resistance low.	Check	MR.6 replaced	Ground		05.00	10.00	15.00	324.00	
						Hrs. to date.			04.05	01.15	05.20	329.20	Total phase 1 171.45. Total phase II 157.35.
						Total			108.20	49.45*	157.35		Total 329.20

* Normal Inspections 13.45
Rectification 36.00

49.45

SECRET

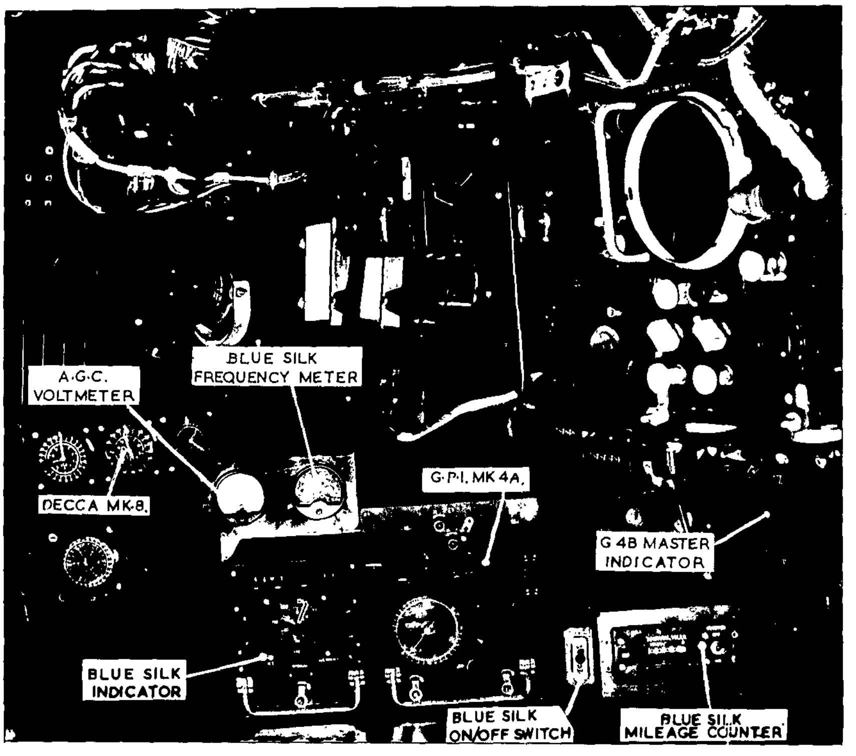


FIG-1 TRIALS EQUIPMENT IN NAVIGATORS STATION

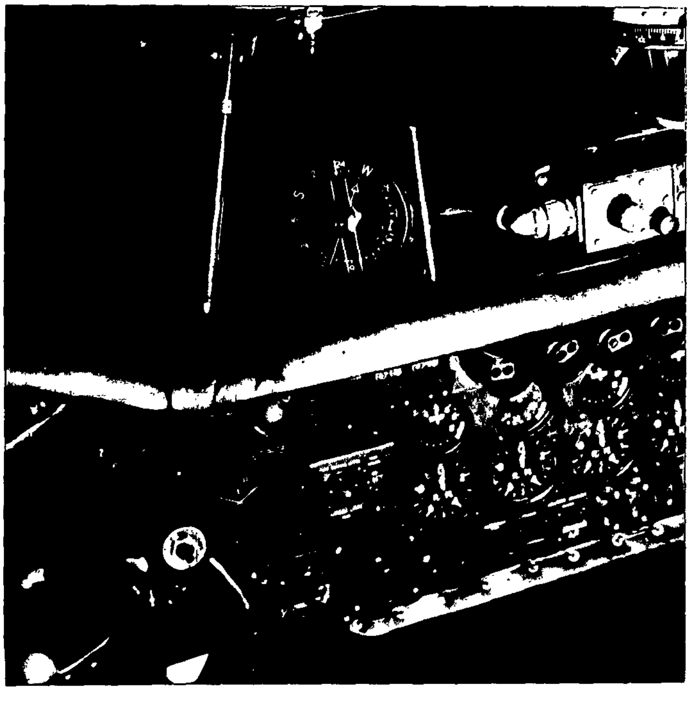
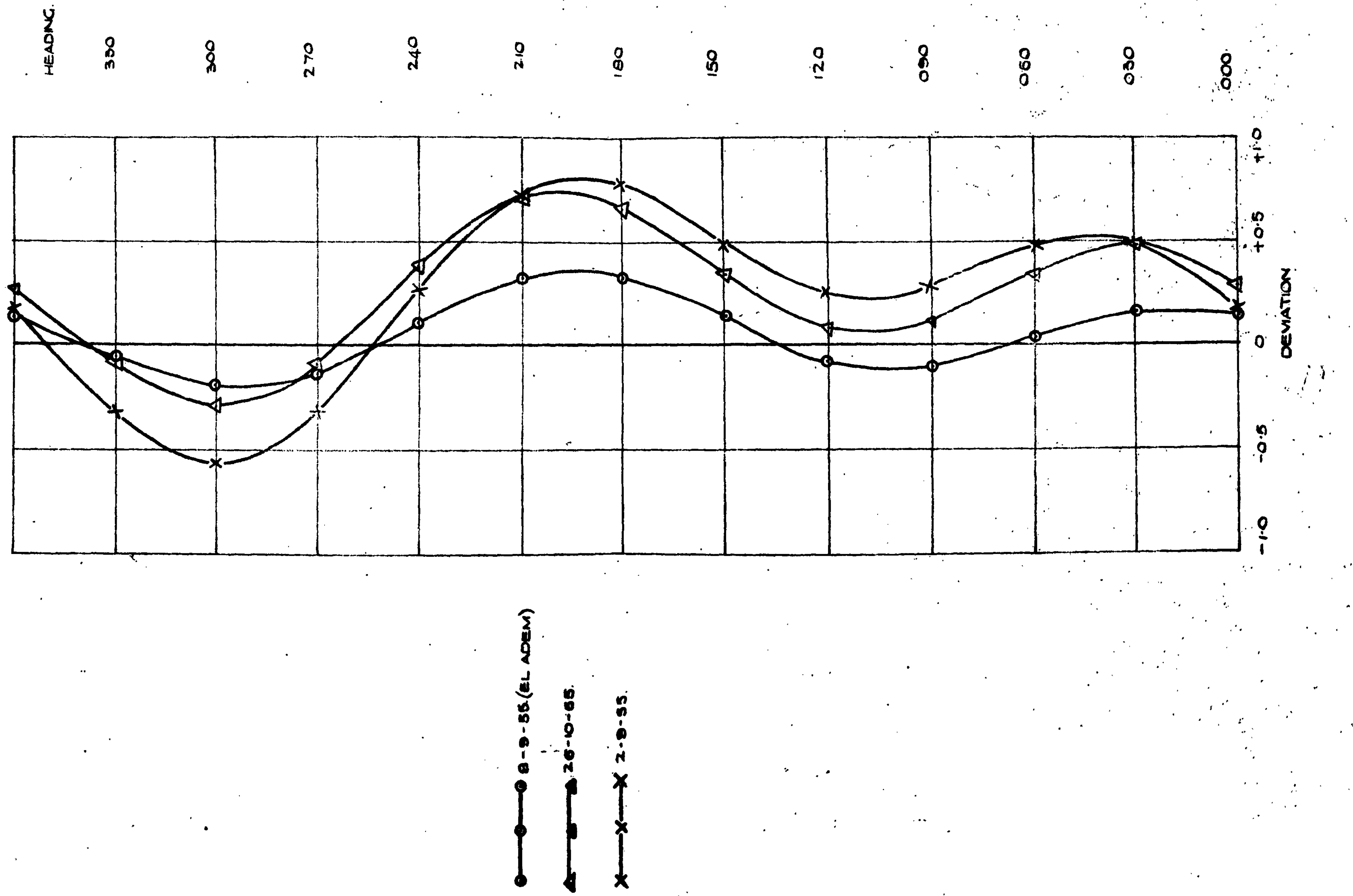


FIG 2-PILOTS TRACK INDICATOR ON INSTRUMENT PANEL COAMING

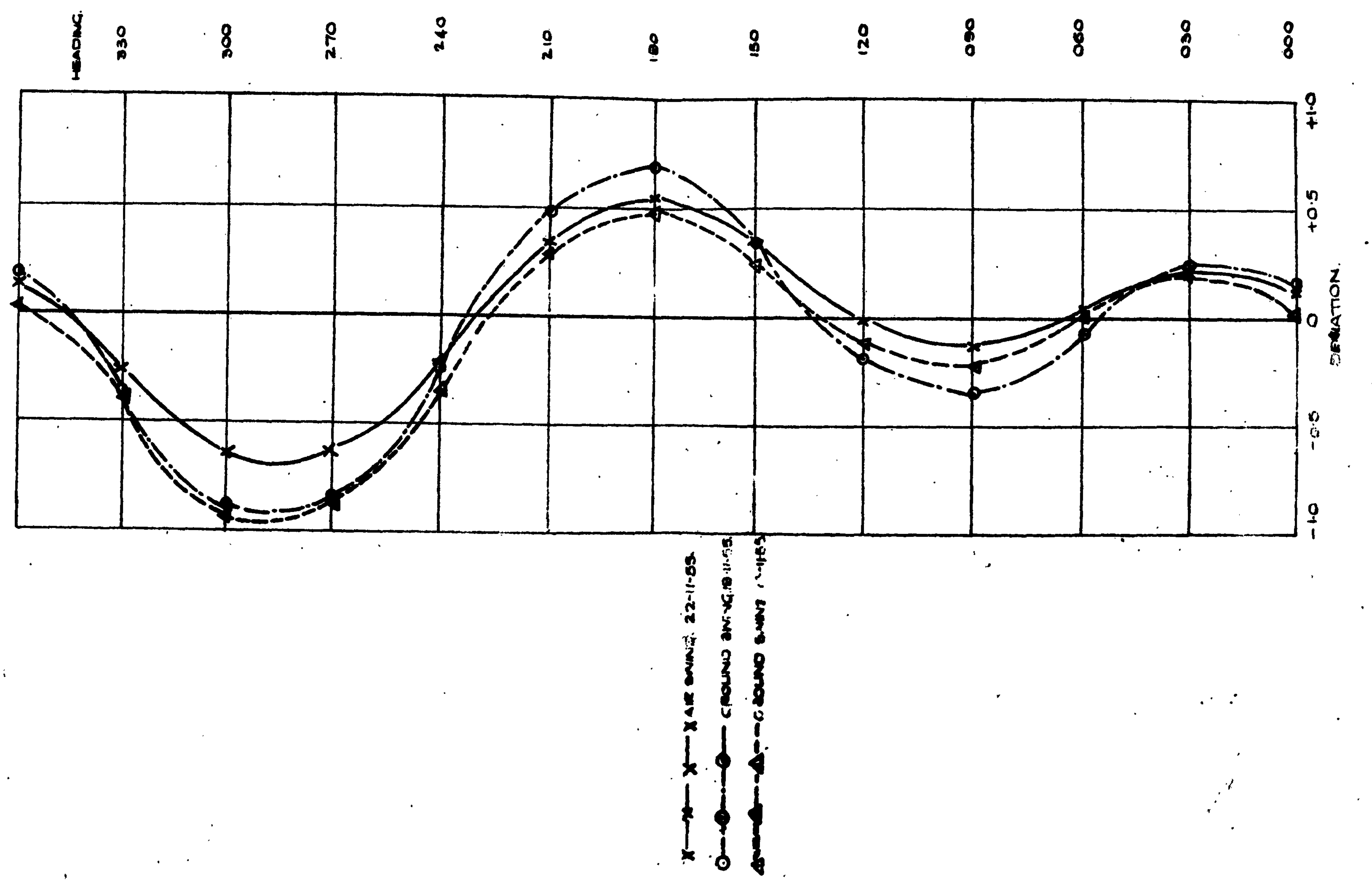
A.A.E.E. NEG No 16260

FIG.3



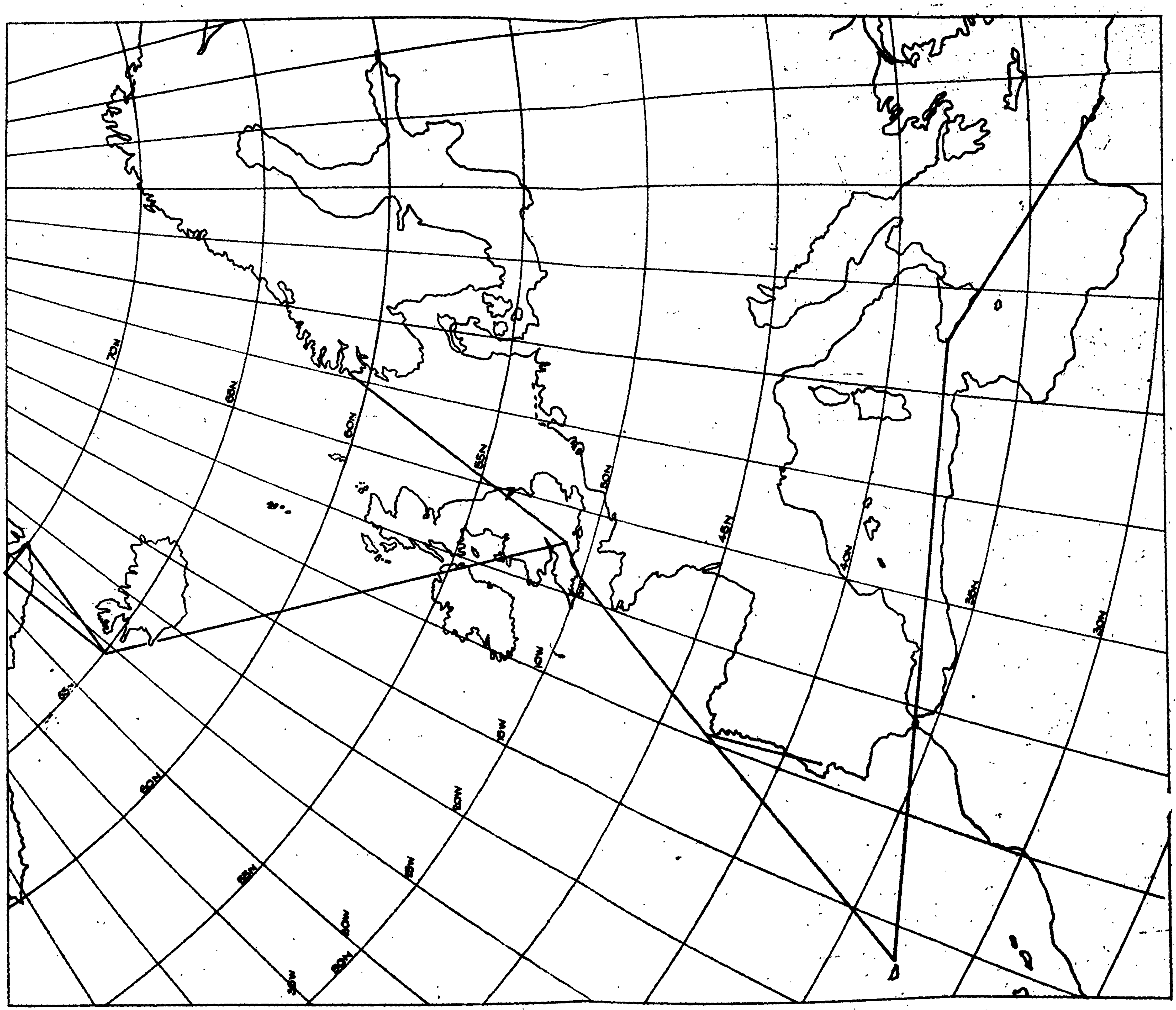
GROUND CALIBRATIONS-GIVB COMPASS.

FIG.4.



COMPARISON OF GROUND & AIR CALIBRATIONS G IVB COMPASS.

FIG.



ROUTES USED DURING THE PHASE 2 FLYING

[dstl]

Information Centre
Knowledge Services
[dstl] *Porton Down*
Salisbury
Wilts
SP4 0JQ
22060-6218
Tel: 01980-613753
Fax 01980-613970

Defense Technical Information Center (DTIC)
8725 John J. Kingman Road, Suit 0944
Fort Belvoir, VA 22060-6218
U.S.A.

AD#: AD101802

Date of Search: 13 February 2009

Record Summary: AVIA 18/1947
Evaluation of Blue Silk/GPI Mk 4A Pt II performance over various terrains and under simulated operational conditions
Former reference (Department): AAEE/TECH 122/N
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